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(54) Route selection and guidance apparatus and method

(57) Route selection and guidance apparatus for a vehicle includes a digital data processor 18 controlled by programs stored in a ROM 30 to select an optimum route between driver-selected journey starting and finishing positions, using driver-selected optimisation criteria. Map data is stored in a storage unit 32, entered manually or verbally by a driver-operable entry module 26. The selected route is stored in the storage unit 32, and serves to provide with an instruction during each route-stage, each instruction being announced to the driver when a vehicle-position feedback signal from a feedback device 40 corresponds with a position reference signal contained in the instruction. Additional signals may be included to cancel an announced instruction and replace it by the next when the position feedback signal corresponds to the additional reference signal.

Instructions are announced vocally 36 or visually 34. Position feedback signals are derived directly or indirectly from position feedback devices 40, which may give output signals dependent upon elapsed-time 40A, distance travelled 40B, or actual vehicle position 40C-40F.

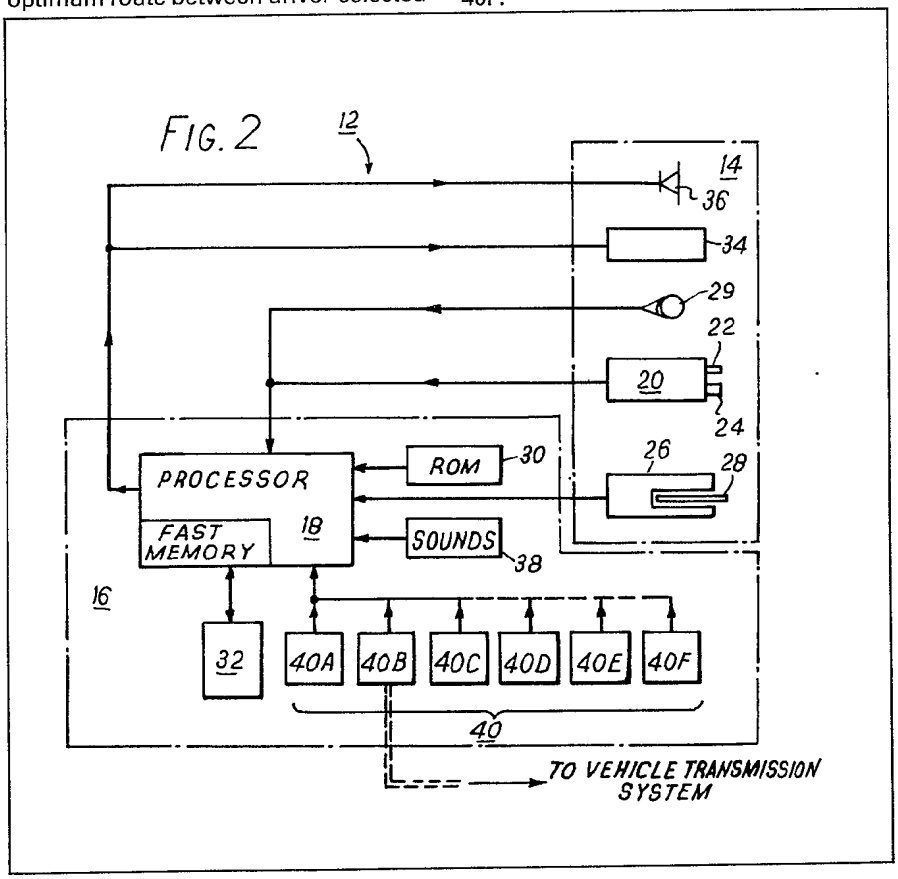

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FIG. 1

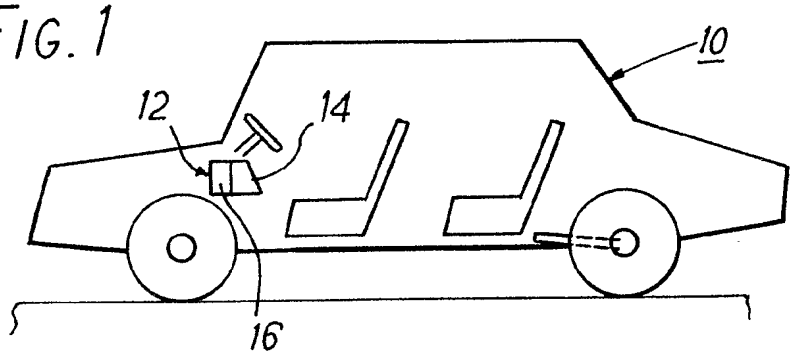
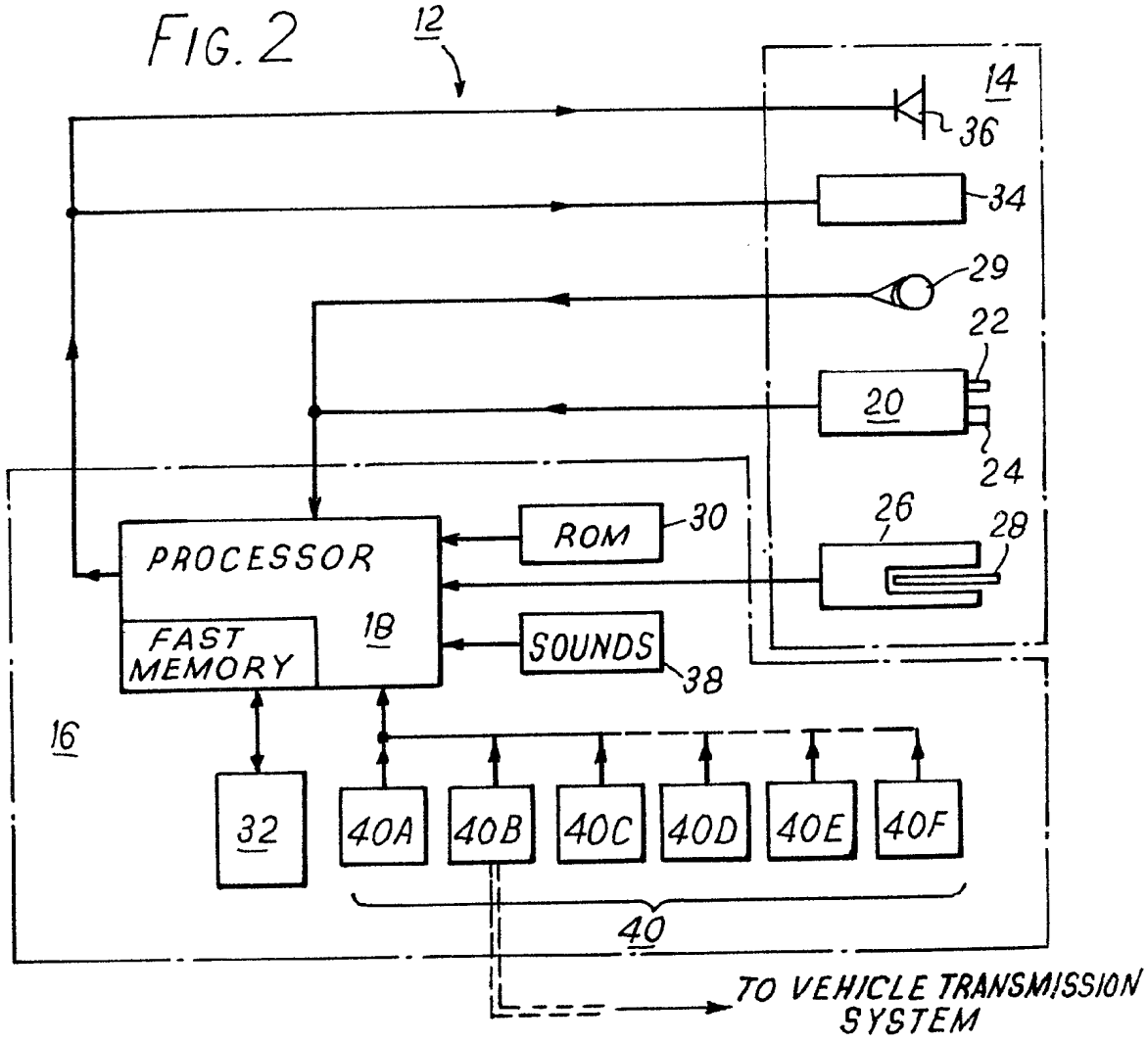

10
12
14
16

FIG. 2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TO VEHICLE TRANSMISSION SYSTEM

SPECIFICATION

Route selection and guidance apparatus and method

This invention relates to an apparatus and method for providing a driver of a driver-controlled vehicle with information identifying successive sections of a route to be followed, so as to enable the vehicle to be driven from a selected starting point to a selected finishing point. In the specification the term "vehicle" is intended to cover any form of moving craft the route of which over land or sea, or in the air, is dependent on a driver or pilot action to direct the craft along successive sections of a selected route.

Though in the description that follows the invention will be described in relation to the driving of a land vehicle along roads, the invention may also be applied to the navigation of boats along waterways or across the open sea, and also to the piloting of an air-craft through the sky.

It has been shown recently by transport planning authorities that in the United Kingdom the distance travelled by all vehicles in getting to their destinations is some 6 per cent greater than that which was actually necessary for the performance of the required journeys. Such an over-travel represents a loss to the United Kingdom economy of some 1500 million pounds. Hence, a means for enabling this over-travel to be reduced would be a substantial benefit to those who make the journeys, and to the UK economy.

The basic source of route information for the modern road vehicle driver has been traditionally the printed map, and from that the driver (or some one acting for him) has determined, according to his own intuitive criteria, and his own personal assessment of factors such as road conditions and congestion, the route that he should follow in making any particular journey.

Thus, the preliminaries to a road journey included the making of an analysis and an assessment of the possible alternative routes between the starting and finishing positions, and a selection of the route to be followed, and possibly the writing down of that route for subsequent reference during the journey. This involved some considerable time and effort, and for best results an up-to-date knowledge of the geography and traffic conditions prevailing on the various route sections shown on the map.

For the private motorist, particularly, this problem of route selection has been aided by the professional motoring organisations, which have provided on request special printed route maps complete with accompanying written instructions for the guidance of the driver or navigator during the course of the journey. Unfortunately, such route maps and instructions usually required the making of a specific request some days before the intended departure on the journey, so that the relevant route could be selected and the relevant map sections and instructions compiled for despatch to the intending traveller.

Furthermore, the following of such a set of route instructions required the driver or nagivator to be ever attentive as to his exact position on the route map and instruction set, so that he could anticipate his arrival at the next mentioned cross-roads or turning. Moreover it was necessary for him to constantly memorize the next guidance instruction apertaining to the next route section.

Though such special route maps and guidance instruction sets were of great benefit to the motorist, they had the disadvantage of involving another party in the selection and preparation of a route and also that once prepared the driver could not expeditiously or easily modify the map and guidance instruction set to deal with unforeseen conditions or events such as for example traffic diversions or adverse road conditions due for example to accidents or weather.

According to a first aspect of the present invention there is provided in or for a vehicle (as hereinbefore defined), a route guidance apparatus comprising:-

(a) *instruction producing means* for producing in sequence from a pre-planned route individual route-stage instructions each defining an action to be taken by a driver of a vehicle at the end of an associated route-stage, each such instruction including a reference signal representing the intended vehicle position at the point along the associated route-stage at which the instruction should be announced to the driver for subsequent action by him;

(b) *feedback signal producing means* for producing feed back signals representative of the progress of the vehicle along the route-stage, each such feedback signal being representative directly or indirectly of the position of the vehicle on said route-stage;

(c) *instruction announcing means* for announcing to the driver, on its being activated, a said instruction represented by output signals of the instruction producing means;

(d) *signal comparison means* for comparing during each said route-stage said reference and feedback signals and for activating said instruction announcing means when said reference and feedback signals correspond, thereby to announce to the driver the instruction associated with the said reference signal, and

(e) activating means for activating said instruction producing means thereby to cause it to produce the next route-stage instruction in the sequence in place of a current one.

Said activating means may be driver-operable; though in a preferred apparatus each route-stage instruction produced by said instruction producing means also includes an additional reference signal which represents the intended vehicle position at the end of the associated route-stage, at which position the driver should act on that instruction; and there is included comparison means for comparing during each route-stage said feedback and additional reference signals and for stimulating said activating means when said feedback and additional reference signals correspond, thereby to cause said instruction producing means to produce the next route-stage instruction in the sequence in place of the current one.

In one form of guidance apparatus according to the present invention said instruction producing means is arranged to store a plurality of sets of route-stage instructions for enabling a driver to be guided along various routes respectively; and said instruction producing means includes driver-operable route selection means for enabling a driver to select from said various routes a specific one along which he wishes to be guided, said instruction producing means being operative on selection of route to a produce in sequence and as required by said activating means the successive route-stage instructions apertaining to the selected route.

Advantageously said route selection means includes driver-operable selection means for identifying the starting and finishing positions of a journey for which guidance is required, and means for automatically selecting from said plurality of sets of route-stage instructions the set having the driver-identified starting and finishing positions, thereby to cause the desired set of route-stage instructions to be produced in sequence and as required by said activating means.

In a preferred form of guidance apparatus according to the present invention said instruction producing means includes

a route compiling means for compiling each said pre-planned route on being required by a driver, and

a driver-operable journey selection means for identifying the starting and finishing positions of a journey for which guidance is required; and

said route compiling means includes -

(a) a data processing means,

(b) a map data storage means for storing map data defining and describing the respective road sections of a road system on a predetermined map section, each such road section being a length of road lying between adjacent points at which an approaching driver has different courses of action open to him,

(c) a program storage means for storing programs for controlling the operation of the data processing means, and for causing it to carry out, on request and according to a predetermined optimization criterion, a route evaluation and selection process to determine an optimum route between the driver-identified journey starting and finishing positions on the said map section, and means for storing that optimum route and announcing route-stage instructions appertaining to it in sequence as required by said activating means.

Preferably, said program storage means has stored within it alternative programs, or program modifiers, for enabling the data processing means to carry out on request route evaluation and selection processes according to any one of a plurality of different optimization criteria, and there is provided driver-operable optimization criterion selection means for selecting for a particular journey to be undertaken the particular optimization criterion or criteria to be used.

Conveniently, said data processing means is also arranged to carry out the functions of the respective comparison means for comparing on the one hand said feedback and reference signals, and on the other hand said feedback and additional reference signals.

Said map data storage means may have associated therewith map data entry means for receiving removable map data storage elements, whereby data appertaining to any desired area of a map may be entered into said map data storage means for use temporarily by said data processing means.

Vocal input means for receiving a driver's spoken input information identifying a journey to be undertaken may be provided, and said data processing means may then be arranged to decode that vocal input information and to act upon it in selecting a route for a journey to be undertaken by the driver.

Preferably, said instruction announcing means is arranged to announce each said route-stage instruction in vocal form, and said data processing means is arranged to produce and/or control signals for vocalizing said instructions.

Said instruction announcing means may be arranged to announce each route-stage instruction in visual form.

Said feedback signal producing means may take any one of a plurality of different forms; for example, an elapsed-time measuring means arranged to be carried by the vehicle and to be activated by said activating means, and to deliver an output vehicle-position-indicating signal dependent on the time that has elapsed since last being activated; or alternatively a distance measuring means arranged to be driven by the vehicle and to be activated by said activating means, and to deliver an output vehicle-position-indicating signal dependent on the distance travelled by the vehicle along the route-stage since last being activated; or alternatively an inertial-guidance position determining means arranged to be carried by said vehicle and to compute from vehicle motion the position of the vehicle, and to provide an output vehicle-position-indicating signal dependent on said position for comparison with position indicating signals constituted by said reference and/or said additional reference signals incorporated in said route-stage instructions; or otherwise a vehicle position determining means arranged to be carried by said vehicle and to compute, from bearings of objects disposed externally of the vehicle on or around the earth's surface, the position of the vehicle, and to provide an output vehicle-position-indicating signal for comparison with position-indicating signals constituted by said reference and/or said additional reference signals incorporated in said route-storage instructions.

Preferably, each said route-stage instruction is represented in electrical signal form, and said reference, additional reference, and feedback signals comprise electrical signals.

According to a second aspect to the present invention a method of guiding a driver of a vehicle (as hereinbefore defined) along a multi-stage route between journey starting and finishing positions, comprises -

(a) generating and storing for said route a sequence of individual route-stage instructions each defining an action to be taken by the driver at the end of the associated route-stage, and each including a reference signal representing the intended vehicle position at the point along the associated route-stage at which the instruction should be announced to the driver for subsequent action by him;

(b) extracting a said instruction that is associated with a first route-stage and holding it ready for announcement to the driver;

(c) generating a feedback signal representative of the progress or position of the vehicle along the route-stage;

(d) comparing said reference and feedback signals,

(e) announcing the extracted instruction to the driver when said reference and feedback signals correspond;

(f) indicating when the vehicle has passed into the next route-stage; and

(g) repeating cyclically in turn the steps (b) to (f) above for the second and subsequent instructions in the sequence.

Each said route-stage instruction generated in said step (a) above may also include an additional reference signal representing the intended vehicle position at the end of the associated route-stage, at which position the driver should act upon that instruction; and

the step (f) above may then comprise comparing said feedback and additional reference signals and indicating when said feedback and additional reference signals correspond that the vehicle has passed into the next route-stage.

Such methods may also include the preliminary step of -

specifying the starting and finishing positions of a journey for which guidance is required, and the criterion or criteria to be used in selecting an optimum route between those positions, and

in the said step (a) said sequence of instructions is obtained by generating from stored map data defining and describing the respective road sections of a road system (each such section being a length of road lying between adjacent points at which an approaching driver has different courses of action open to him) the optimum route between the specified starting and finishing positions and based on the specified optimization criterion or criteria, and storing the route-stage instructions for the successive route-stages making up that optimum route.

Other features and advantages of the present invention will appear from the description that follows hereafter, and from the claims appended at the end of that description.

One embodiment of the present invention for providing route selection and driver guidance instructions in or for a road vehicle will now be described by way of example and with reference to the accompanying diagrammatic drawings, in which:-

Figure 1 shows in outline a motor car in which a route selection and driver guidance system according to the present invention is installed; and

Figure 2 shows schematically the various components of that system, and the manner of their interconnection.

Referring now to the drawings, a motor car 10 has installed in it a route selection and driver guidance system 12, which includes a drivers' console 14 fitted in a forward position convenient for a driver to operate, obseve and hear, and an associated equipment module 16 which is mounted preferably alongside the console, though if required its constituent components could be mounted elsewhere in or around the car.

The system 12 is shown in more detail in Figure 2, from which it will be seen to include a digital data processor 18 which is connected to receive input information concerning a route to be determined from

(a) a driver's function control and data entry module 20 having "function control" push-buttons 22, and "data entry" keys 24,

(b) a "map data" input module 26 for receiving a magnetic storage element 28 (for example a tape or disc) carrying data defining, describing and qualifying each and all of the road sections (i.e. lengths of road between pairs of adjacent road intersections) included in a particular map section of the United Kingdom road system, and

(c) a driver's microphone 29 for inputting a driver's vocal instructions.

Associated with the data processor 18 is a read-only, random-access, memory ("ROM"), in which is stored the operating programs for controlling the operations of the process, and various programs (and program modifiers) for use in the processor for determining alternative routes between driver-specified starting and finishing positions, according to any one or more of a variety of selected overriding criteria, e.g. shortest distance, minimum running time, best fuel consumption, avoidance of urban roads or motorways.

Also associated with the processor 18 is a data storage unit 32 (preferably of the random-access kind) for storing data inputted to it via the processor 18 by the map data input module 26.

The output of the processor 18 is transmitted to a driver's visual display unit 34 for providing visual guidance instructions, and/or to a driver's loudspeaker (or earphone) 36 for providing vocal guidance instructions. A vocabulary of sound producing signals (representing various basic phrases, words and syllables) is stored in a sound vocabulary unit 38 for use at appropriate times by the processor in formulating vocal guidance instructions for transmission over the loudspeaker.

Guidance instructions to be transmitted to the driver via the display and/or loudspeaker are coordinated with the progress (that is the position) of the vehicle along the selected route, by means of output signals

provided by one or more position feed-back devices 40. Such devices may comprise on the one hand a relatively simple "elapsed-time" indicator 40 A, or a "distance-travelled" indicator 40 B driven from a transmission system (e.g. a propeller shaft) of the vehicle. Alternatively the position feed-back device may comprise a more sophisticated device such as for example an integration system 40 C incorporating means for integrating changes in vehicle compass heading and speed and providing in response thereto vehicle position map coordinates; or an inertial navigating system 40 D likewise arranged to provide vehicle position map coordinates; or an earth satellite navigation system 40 E arranged to provide an output derived from bearing observations of earth satellites; or a radio navigation system 40 F for providing output signals based on the observation of bearings of specific radio beacons.

The system 12 is connected for power supply through an ON/OFF switch (not shown) to the electrical system of the vehicle.

The "function control" buttons 22 (referred to hereafter as "function buttons") include the following, for effecting the following operations:-

(a)	an "Advance" button	–	proceed to next guidance instruction;
(b)	a "Step-back" button	–	step back to the preceding road section (this allows the instructions for that road section to be reviewed);
(c)	a "Confirm" button	–	repeat current instruction;
(d)	a "Start" button	–	give initial instruction for starting the journey;
(e)	a "New Data" button	–	receive new starting and finishing position data about to be keyed in;
(f)	a "CANCEL" button	–	cancel the previously stored selected route and adopt the newly selected route; and
(g)	a "Calibrate" button	–	adjust multiplier to recalibrate the distance output signals derived from the distance feedback device 40 B.

The data-entry keys 24 include keys for enabling the driving to feed-in:-

(a) the names of the starting and finishing positions of the desired journey (or alternatively codes representing or designating those names, for example the map coordinates of those respective positions);

(b) which of the various available optimizing criteria is/are to be used in assessing and selecting the optimum route from the various possible routes;

(c) other data such as latest running cost per mile based on car and engine size, and the latest fuel prices.

The map data storage element 28 incorporates for every road section in a particular map section data comprising:-

(1) the map coordinates of the ends of the road section;
(2) the length of that section;
(3) the road name (if any);
(4) the road number (if any);
(5) the section travelling times using the respective criteria;
(6) the costs of travelling along the section for each of the travelling times referred to at (5) above; and
(7) the direction of the section.

In use, after first energizing the system 12, the driver wishing to travel between starting and finishing points A and B on the same map section selects the map storage element 28 appropriate to that section and inserts it into the map data input module 26. Thereafter, he activates that module to cause the map data to be read from that storage element via the processor into the data storage unit 32, where it is stored for use later.

Then using appropriate data entry keys 24 the driver keys-in the identities of the starting and finishing places A and B, and also the criterion/criteria that he wishes the system to use in determining the selection of his route, for example that he wishes to travel from A to B in the shortest running time (rather than for example along the shortest distance).

Now, having been given the starting and finishing positions, the processor 18 proceeding under the

control of the ROM 30 and using the data defining, describing and qualifying the various road sections as stored in the data storage unit 32, assembles in turn various possible routes between the starting and finishing positions, and then using the selected optimization criterion/criteria (stored in the ROM) compares one route with another to find that route which provides the optimized selected condition/conditions.

The identities of the road sections constituting this optimized route are then stored in the data storage unit 32 for subsequent use in guiding the driver section by section along that route.

On depression of the "start" button, the first and second road sections of the stored route are extracted from the data storage unit 32 together with their relevant particulars, and a first guidance instruction identifying the road, and its direction, to be taken in order to leave A is formulated and announced to the driver. Thereupon the journey may be commenced.

A second guidance instruction, to instruct the driver what action is required at the junction of the first and second road sections, is also formulated and stored, until replaced later, in the data storage unit 32.

Alongside the second instruction are assembled (a) the distance to be travelled by the vehicle before the second instruction is to be announced to the driver, and preferably also (b) the distance at which this second instruction is to be acted upon by the driver. The said distances may also be accompanied, if required, by the map coordinates of the respective positions at which said second instruction is to be announced and acted upon.

These distances and/or corresponding map coordinates are compared continuously in the processor 18 with the respective distances and/or map coordinates that are being supplied continuously by the corresponding vehicle position feed-back devices 40, and respective "annunciation" and "change road section" control signals are emitted by the processor when the corresponding feed-back distances and/or map coordinates equate with the respective stored distances and/or map coordinates.

The first control signal ("announce guidance instruction") operates to cause the said second guidance instruction to be announced to the driver, so that he may shortly act upon it, whilst the second of the control signals ("change road section") is used to automatically cancel the second instruction, preferably only if the system detects or has been advised by the driver that the instruction has been correctly acted upon, or if the system has no indication that the instruction has been carried out or properly carried out, to advise the driver of the need for (and also the nature of) appropriate corrective action.

Instead of providing for the automatic cancellation of the second guidance instruction, by causing the processor to access the vehicle's movement at and about the position for taking action, and comparing it with the guidance instruction, such cancellation may be made dependent instead upon action (for example depressing the "advance" button) by the driver to indicate that he has acted upon that guidance instruction and is now ready to receive at an appropriate instance the next (third) guidance instruction.

The third guidance instruction is produced by the processor 18 after first requesting and receiving into its own internal memory from the data storage unit 32 the identity and relevant particulars of the third road section, that third instruction then being deduced and formulated by the processor from a comparison of the data concerning the junctions of the second and third road sections with each other. This third instruction includes the said distances (and where desired, the corresponding map positions) to the respective positions for announcing, and, where appropriate, for acting upon this third guidance instruction.

The third guidance instruction is announced to the driver automatically when the processor detects coincidence of the distance travelled along the second road section by, or of the position on that road section of, the vehicle, with the annunciation distance or position identified within the third guidance instruction.

Further successive guidance instructions are produced in turn by the processor each time an indication (automatic or driver-originated) is received by the processor that the last instruction has been correctly acted upon, and the identity and relevant particulars of the next road section ahead have been subsequently received by the processor from the data storage unit 32.

Each successive guidance instruction is announced to the driver automatically when the processor detects coincidence of the distance travelled along a current road section by, or of the position on that road section of, the vehicle, with the annunciation distance or position identified with that guidance instruction.

Typical instructions and their associated distance data for travelling from the town of Guildford to the town Dorking are shown in the following Table.

TABLE

Route - Guildford to Dorking

Inst'n No.	Section Distance (Miles)			Total Distance (Miles)
(1)	0.0	Leave Guildford Follow signs for Merrow	(Direction NE) on A 246	0.0
(2)	0.3	Bear Right Follow signs for Merrow	(Direction E) keep on A 246	0.3
(3)	1.2	At Merrow Straight on	(Direction NE) keep on A 246	1.5
(4)	1.0	Turn Right Follow signs for Dorking, Reigate, Newlands Corner	(Direction SE) onto A 25	2.5
(5)	1.2	At Newlands Corner Straight on Follow signs for Dorking, Reigate, Shere	(Direction SE) keep on A 25	3.7
(6)	2.1	At Shere Bear Left Follow signs for Dorking, Reigate, Abinger Hammer	(Direction E) keep on A 25	5.8
(7)	3.2	At Abinger Hammer Bear Left Follow signs for Dorking, Reigate, Westcott	(Direction NE) keep on A 25	9.0
(8)	2.6	At Westcott Straight on Follow signs for Dorking, Reigate, Redhill	(Direction NE) keep on A 25	11.6
(9)	2.4	At Dorking		14.0

In the event that the driver finds that road, weather, or other conditions are undesirably impeding his progress along the route, it is possible for him to request the processor, whilst continuing to store the presently selected route, to work out a new route between his present vehicle position and his destiantion B, either via some driver-selected intermediate position which lies off the present selected route, or avoiding the road sections ahead on which travelling difficulties are known (for example, from a broadcast traffic news bulletin) to exist. The newly selected route can be adopted by depressing the "Cancel" button.

In the event that a projected journey extends from one map section to another, a driver must seek a route on the first map section to some driver-selected, convenient, intermediate position on or near the boundary of that map section, and after completing that part of his journey on the processor-selected route, enter the map data appertaining to the second map section (after first inserting the appropriate map storage element 28), and then enter that intermediate position as his starting position for the second part of his journey, as well as his final destination. Thereby he will be guided along an optimized route between the intermediate position and the final destination.

Alternatively, the apparatus may be modified to include a larger data storage unit 32 capable of holding the data of two map sections, and then to receive successive map data entries from the two map sections as stored on two different map data storage elements 28. In that way, the processor is enabled to analyse and select an optimum route between starting and finishing points which are disposed on adjacent map sections respectively.

The guidance instructions may be announced to the driver either vocally via the loudspeaker or earphone 36, or visually via the visual display unit 34, or they may be announced simultaneously using both visual and vocal annunciating means. The visual display unit 34 may be arranged to display an instruction only once and for a limited period of time, or repeatedly at intervals during the period of its currency.

Furthermore, the processor may be arranged to maintain the visual display unit energized to display the next guidance instruction from the time of its formulation by the processor until the time of its subsequent cancellation by the automatic or driver-produced "action-acted-upon" signal.

Alternatively, the processor may be arranged to energize the visual display unit only temporarily on formulation of the next guidance instruction, and to subsequently re-energize it at the said detected time for announcing that instruction.

Where an instruction is not displayed continuously, as mentioned above, from the time of its formulation to the time of its cancellation, the driver has the option at all times to look ahead by depressing the "confirm" function button, whereby to cause the current (that is the next to be acted upon) instruction to be announced temporarily by either or both of the vocal and visual means (or in the case of the visual means, even through to the time of acting on that instruction).

The processor may, if desired, be connected with the control system for operating the vehicle's direction indicators, and be arranged to automatically energize at the appropriate moment the appropriate direction indicators in accordance with the current guidance instruction.

It will be appreciated from the foregoing that with the system specifically described above:-

(a) the driver has available to him in his vehicle, in the form of the map storage elements 28, a complete road system of the relevant area, which system can be searched for any journey between any two points in that road system, according to one or more optimization criteria, and that the searching can be carried out very quickly and at any time before or during a journey to meet changed or changing conditions, as forecast or actually met on the roads;

(b) the driver is relieved of the need to keep track of his position on the map and moreover to memorize successive instructions; and

(c) the selection of the optimum route is carried out methodically, reliably, and exhaustively, and is based on information recorded in map storage elements that are capable of being updated from time to time as the need arises.

The data storage unit 32 may be of any suitable kind, including those of the sequential access variety, for example a bubble memory.

The map data may be recorded on any convenient form of data storage element 28, for example on discs or tapes. Tapes offer the advantage that they could be inserted in and read by tape decks that are increasingly being installed in vehicles for the purpose of playing music and speech.

Alternatively, the map data storage element may take the form of a "library module" chip storage device, similar to those now being used in small pocket calculators.

Whilst the map data storage elements 28 have been disclosed above as covering various contiguous, and possibly overlapping, sections of a road system, it should be appreciated that such sections of a road system may each cover a fairly large area of the country, or alternatively a much smaller area. The former may be used to enable route selection and guidance over long distances, whilst the latter would be suitable for enabling route selection and guidance over relatively short distances, for example for navigating a route through a town or urban area. Hence, a complete library of map data storage elements would comprise a series of the former elements, covering the whole of the country or an area in question (e.g. the United Kingdom), and a series of the latter elements covering the respective large towns and urban areas. In fact, using the latest techniques for storing large volumes of data in a compact storage medium, it is feasible to have the data for the whole of a country such as the United Kingdom recorded on a single, compact memory element which is permanently connected into the processor. To supplement that storage unit, map data for

specific towns could be supplied on individual storage elements 28 for insertion into the map data entry module 26.

The processor may also be arranged to display on the visual display unit the increasing total mileage of a distance covered on a journey so far, together if desired with the increasing distance covered since the last guidance instruction was cancelled, (or if desired the decreasing distance to be travelled before the next point of which the current guidance instruction is to be acted upon).

Since the distance-travelled measuring means 40 B driven from the car's transmission system is dependent for its accuracy on the state of the car's tyres and their inflation pressures, it may be necessary from time to time to adjust the calibration of that distance travelled measuring means. This is performed by appropriate manipulation of the "calibrate" function button 22 to adjust a multiplying constant for said distance travelled measuring means. Such re-calibration would normally be made en route after a known distance has been travelled.

The data processor may also be arranged to compute indications of average running speeds, from the indications of the distance-travelled measuring means 40 B and elapsed-time measuring means 40 A, for the total journey so far, and/or for the part of the current road section so far covered. Such average speeds would be displayed on the visual display unit, and could be vocally announced at the time of giving each guidance instruction to the driver.

Whilst the simple elapsed-time or distance measuring feedback devices (40 A or 40 B) may suffice for providing adequate feed-back data, the provision in addition of one of the more complex position feedback devices 40 C to 40 F (for example the inertial guidance system 40 D) has the advantage of providing a back-up for the simple fee-back device, and, moreover, that a compass heading is also provided as an additional checking means.

Though the system described above provides for both vocal and visual announcement of guidance instructions, in a simpler version of the system it is preferred to provide vocal announcements in preference to visual announcements.

Whereas the use of the system has been described in relation to the driver keying-in his information concerning the starting and finishing positions, the optimization criteria to be used, and etc., the driver may alternatively, and preferably, input his information vocally by means of the microphone 29. For this purpose, the processor is programmed to compare the driver's spoken instructions, using a specific and limited vocabulary of phrases, words and syllables, as stored in the vocabulary unit 38, with the contents of that unit, and to use those decoded vocal instructions in place of the alternative keyed-in information that the driver might otherwise have used.

The vocal mode of communication between the driver and the processor is preferred since it involves less distraction of the driver's attention from his prime task of driving the vehicle. To produce the vocal guidance instructions for the driver, the processor 18 is caused to select and string together sounds taken from, or synthesized in accordance with, those stored in the vocabulary unit 38, the instructions for the formulation of those vocal instructions being produced by the processor.

In a system using the elapsed-time measuring device 40 A, it is necessary to provide adjustment means (like those mentioned above in respect of the distance-travelled measuring device 40 B) for adjusting the calibration of the device 40 A from time to time, to match the calibration to the known or expected average speed of the car.

Whereas in the above-described system, guidance instructions have been derived from a pre-planned route that has been compiled on demand by the data processor, in a simpler system the data processor is replaced by a storage means housing a plurality of sets of pre-planned routes, each comprising a sequence of route-storage instructions, and an associated selection means operable by the driver for selecting which of the several routes he wishes to follow. That simpler system operates in a manner generally similar to that described above to announce and cancel each successive guidance instruction of the selected route at appropriate times in dependence upon the progress of the car.

CLAIMS

1. In or for a vehicle (as hereinbefore defined), a route guidance apparatus comprising:-

(a) *instruction producing means* for producing in sequence from a pre-planned route individual route-stage instructions each defining an action to be taken by a driver of a vehicle at the end of an associated route-stage, each such instruction including a reference signal representing the intended vehicle position at the point along the associated route-stage at which the instruction should be announced to the driver for subsequent action by him;

(b) *feedback signal producing means* for producing feed back signals representative of the progress of the vehicle along the route-stage, each such feedback signal being representative directly or indirectly of the position of the vehicle on said route-stage;

(c) *instruction announcing means* for announcing to the driver, on its being activated, a said instruction represented by output signals of the instruction producing means;

(d) *signal comparison means* for comparing during each said route-stage said reference and feedback signals and for activating said instruction announcing means when said reference and feedback signals correspond, thereby to announce to the driver the instruction associated with the said reference signal, and

(e) activating means for activating said instruction producing means thereby to cause it to produce the next route-stage instruction in the sequence in place of a current one.

2. Apparatus according to Claim 1, wherein said activating means is driver-operable.

3. Apparatus according to Claim 1, wherein each route-stage instruction produced by said instruction producing means also includes an additional reference signal which represents the intended vehicle position at the end of the associated route-stage, at which position the driver should act on that instruction; and including comparison means for comparing during each route-stage said feedback and additional reference signals and for stimulating said activating means when said feedback and additional reference signals correspond, thereby to cause said instruction producing means to produce the next route-stage instruction in the sequence in place of the current one.

4. Apparatus according to any preceding claim, wherein said instruction producing means is arranged to store a plurality of sets of route-stage instructions for enabling a driver to be guided along various routes respectively; and

wherein said instruction producing means includes driver-operable route selection means for enabling a driver to select from said various routes a specific one along which he wishes to be guided, said instruction producing means being operative on selection of a route to produce in sequence and as required by said activating means the successive route-stage instructions apertaining to the selected route.

5. Apparatus according to Claim 4, wherein said route selection means includes driver-operable selection means for identifying the starting and finishing positions of a journey for which guidance is required, and means for automatically selecting from said plurality of sets of route-stage instructions the set having the driver-identified starting and finishing positions, thereby to cause the desired set of route-stage instructions to be produced in sequence and as required by said activating means.

6. Apparatus according to any one of the Claims 1 to 3, wherein said instruction producing means includes

a route compiling means for compiling each said pre-planned route on being required by a driver, and

a driver-operable journey selection means for identifying the starting and finishing positions of a journey for which guidance is required,

said route compiling means including -

(a) a data processing means,

(b) a map data storage means for storing map data defining and describing the respective road sections of a road system on a predetermined map section, each such road section being a length of road lying between adjacent points at which an approaching driver has different courses of action open to him,

(c) a program storage means for storing programs for controlling the operation of the data processing means, and for causing it to carry out, on request and according to a predetermined optimization criterion, a route evaluation and selection process to determine an optimum route between the driver-identified journey starting and finishing positions on the said map section, and means for storing that optimum route and announcing route-stage instructions appertaining to it in sequence as required by said activating means.

7. Apparatus according to Claim 6, wherein said program storage means has stored within it alternative programs, or program modifiers, for enabling the data processing means to carry out on request route evaluation and selection processes according to any one of a plurality of different optimization criteria, and wherein there is provided driver-operable optimization criterion selection means for selecting for a particular journey to be undertaken the particular optimization criterion or criteria to be used.

8. Apparatus according to Claim 6 or Claim 7, wherein said data processing means is also arranged to carry out the functions of the respective comparison means for comparing on the one hand said feedback and reference signals, and on the other hand said feedback and additional reference signals.

9. Apparatus according to any one of the Claims 6 to 8, wherein said map data storage means has associated therewith map data entry means for receiving removable map data storage elements, whereby data appertaining to any desired area of a map may be entered into said map data storage means for use temporarily by said data processing means.

10. Apparatus according to any one of the claims 6 to 9, including a vocal input means for receiving a driver's spoken input information identifying a journey to be undertaken, and wherein said data processing means is arranged to decode that vocal input information and to act upon it in selecting a route for a journey to be undertaken by the driver.

11. Apparatus according to any one of the Claims 6 to 10, wherein said instruction announcing means is arranged to announce each said route-stage instruction in vocal form, and wherein said data processing means is arranged to produce and/or control signals for vocalizing said instructions.

12. Apparatus according to any one of the Claims 1 to 5, wherein said instruction announcing means is arranged to announce each said route-stage instruction in vocal form.

13. Apparatus according to any one of the claims 10 to 12, wherein said instruction announcing means is also arranged to announce each route-stage instruction in visual form.

14. Apparatus according to any preceding claim, wherein said feedback signal producing means comprises an elapsed-time measuring means arranged to be carried by the vehicle and to be activated by said activating means, and to deliver an output vehicle-position-indicating signal dependent on the time that has elapsed since last being activated.

15. Apparatus according to any one of the Claims 1 to 13, wherein said feedback signal producing means

comprises a distance measuring means arranged to be driven by the vehicle and to be activated by said activating means, and to deliver an output vehicle-position-indicating signal dependent on the distance travelled by the vehicle along the route-stage since last being activated.

16. Apparatus according to any one of the Claims 1 to 13, wherein said feedback signal producing means comprises an inertial-guidance position determining means arranged to be carried by said vehicle and to compute from vehicle motion the position of the vehicle, and to provide an output vehicle-position-indicating signal dependent on said position for comparison with position indicating signals constituted by said reference and/or said additional reference signals incorporated in said route-stage instructions.

17. Apparatus according to any one of the Claims 1 to 13, wherein said feedback signal producing means comprises a vehicle position determining means arranged to be carried by said vehicle and to compute, from bearing of objects disposed externally of the vehicle on or around the earth's surface, the position of the vehicle, and to provide an output vehicle-position-indicating signal for comparison with position-indicating signals constituted by said reference and/or said additional reference signals incorporated in said route-storage instructions.

18. Apparatus according to Claim 14, including driver-operable adjustment means for adjusting the callibration of said elapsed-time measuring means in dependence upon and to compensate for variations in average speed of the vehicle's travel.

19. Apparatus according to Claim 15, including driver-operable adjustment means for adjusting the calibration of said distance measuring means in dependence upon and to compensate for variations in the effective road wheel diameter of a road vehicle in or for which said guidance apparatus is intended to be used.

20. Apparatus according to any one of the Claims 14 to 19 when appended to Claim 6 (as dependent itself on Claim 3), or to any other claims that is dependent directly or indirectly on Claim 6 (as dependent itself on Claim 3), wherein said data processing means is programmed to compare with each route-stage instruction the vehicle motion in the vicinity of the said point at which said instruction should be acted upon, and to advise the driver of any lack of correspondence between the said vehicle motion and the said associated instruction.

21. Apparatus according to any preceding claim, wherein each said route-stage instruction is represented in electrical signal form, and said reference, additional reference, and feedback signals comprise electrical signals.

22. A method of guiding a driver of a vehicle (as hereinbefore defined) along a multi-stage route between journey starting and finishing positions, comprising -

(a) generating and storing for said route a sequence of individual route-stage instructions each defining an action to be taken by the driver at the end of the associated route-stage, and each including a reference signal representing the intended vehicle position at the point along the associated route-stage at which the instruction should be announced to the driver for subsequent action by him;

(b) extracting a said instruction that is associated with a first route-stage and holding it ready for announcement to the driver;

(c) generating a feedback signal representative of the progress or position of the vehicle along the route-stage;

(d) comparing said reference and feedback signals,

(e) announcing the extracted instruction to the driver when said reference and feedback signals correspond;

(f) indicating when the vehicle has passed into the next route-stage; and

(g) repeating cyclically in turn the steps (b) to (f) above for the second and subsequent instructions in the sequence.

23. A method according to Claim 22, wherein each said route-stage instruction generated in said step (a) above also includes an additional reference signal representing the intended vehicle position at the end of the associated route-stage, at which position the driver should act upon that instruction; and

wherein the step (f) above comprises comparing said feedback and additional reference signals and indicating when said feedback and additional reference signals correspond that the vehicle has passed into the next route-stage.

24. A method according to Claim 22 or Claim 23, including the preliminary step of -

specifying the starting and finishing positions of a journey for which guidance is required, and the criterion or criteria to be used in selecting an optimum route between those positions, and

wherein in the said step (a) said sequence of instructions is obtained by generating from stored map data defining and describing the respective road sections of a road system (each such section being a length of road lying between adjacent points at which an approaching driver has different courses of action open to him) the optimum route between the specified starting and finishing positions and based on the specified optimization criterion or criteria, and storing the route-stage instructions for the successive route-stages making up that optimum route.

25. A route guidance apparatus substantially as hereinbefore described with reference to and illustrated in the accompanying drawings.

26. A route guidance method substantially as hereinbefore described with reference to and as illustrated by the accompanying drawings.

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